The City of Stuart (City) has developed an ambitious schedule of projects and has been very successful in acquiring funding from different sources to accomplish them. The City has installed 21 baffle boxes throughout the City and has purchased a cleanout vacuum truck for maintenance. The City has integrated their stormwater retrofit projects into a comprehensive long range planning effort. The total budget for these projects exceeds $13 million.

Vacuum Truck for Baffle Box Cleanout/Maintenance

The City's initial efforts were the East Stuart Infrastructure Improvements began in 1993 with the reconstruction and expansion of major stormwater retention areas and sediment cleanup of the upper reaches of <u>Frazier Creek</u>. A weir and a retention pond were installed to treat drainage

Frazier Creek Stormwater Retrofit

from a large portion of the City's older developed area. Exotic removal and habitat restoration needs were evaluated and also incorporated into this project by the City. More recently, additional improvements have been completed that include expansion of the original pond by 1.8 acres to create a retention lake, and exotic and muck removal from the lower portion of the creek to its confluence with the SLE.

The City revised its approach to water quality planning to the watershed basis, because each basin offers unique opportunities. The City has not conducted extensive water quality sampling in each basin, but has elected to implement the most cost-effective and documented Best Management Practices suitable to the individual characteristics of each basin. Additional projects are underway by the City of Stuart within the Poppleton Creek, Haney Creek, Anchorage, Krueger Creek and Fork Road basins. The Pine Riverdale Retrofit proposes construction of a dry retention area over existing vacant property in an older platted subdivision within the City. The Airport Ditch Project began in 1993 as a joint City/County drainage project to remedy flooding in an existing residential area, and evolved into a complete water quality retrofit of a very large urban basin.

Anchorage Basin – City of Stuart

Martin County has also been very proactive in implementing large and small stormwater projects. Projects such as Willoughby Creek Improvement involves removing a minimum of 40,000 cubic yards of muck sediments to provide improved water quality and navigation. Dredged material will be used to build noise abatement structures at Witham Field. A smaller but very important project is the Palm Lake Park Stormwater Retrofit. This 125-acre project is located in the Palm Lake Park subdivision in the north Stuart area. The retrofit is designed to improve water quality and reduce chronic flooding in this older development through the improvement of swales and renovation of the existing retention pond.

Additional projects in Martin County include Old Palm City, 30th Street Stormwater improvements, Phase I, the Poinciana Gardens Stormwater Retrofit Project, and the Fisherman's Cove Drainage Study.

Regional Projects

Best Management Practices (BMPs). As outlined in the Florida Watershed Restoration Act (1999), Florida agriculture is encouraged to develop effective voluntary BMPs to help meet state water quality goals. The efforts of the Indian River Citrus BMP Implementation Committee, a collaborative public/private group, to guide the process for voluntary implementation of citrus BMPs in the watershed were discussed previously in Chapter 6. Additional information can be obtained from the following website:

http://www.irrec.ifas.ufl.edu/Bomanpdf/BMP%20Implementation%20-%20Annual%20Report.pdf

Other examples of voluntary BMP implementation are the recently sponsored "Canal Watch" program that will combine periodic monitoring and citizen reporting at sites throughout the watershed. For additional details see http://www.irrec.ifas.ufl.edu/.In the urban areas of the watershed, a new program called "Adopt a Drop" is being piloted by the St. Lucie River Initiative (The Initiative) Figure 7-15. This program focuses on gathering site specific information by engineers on non-point source pollution to the SLE & River, for residential neighborhoods and businesses. The information is then analyzed and mapped to provide analysis and potential improvements to homeowners and businesses with respect to non-point source impacts.

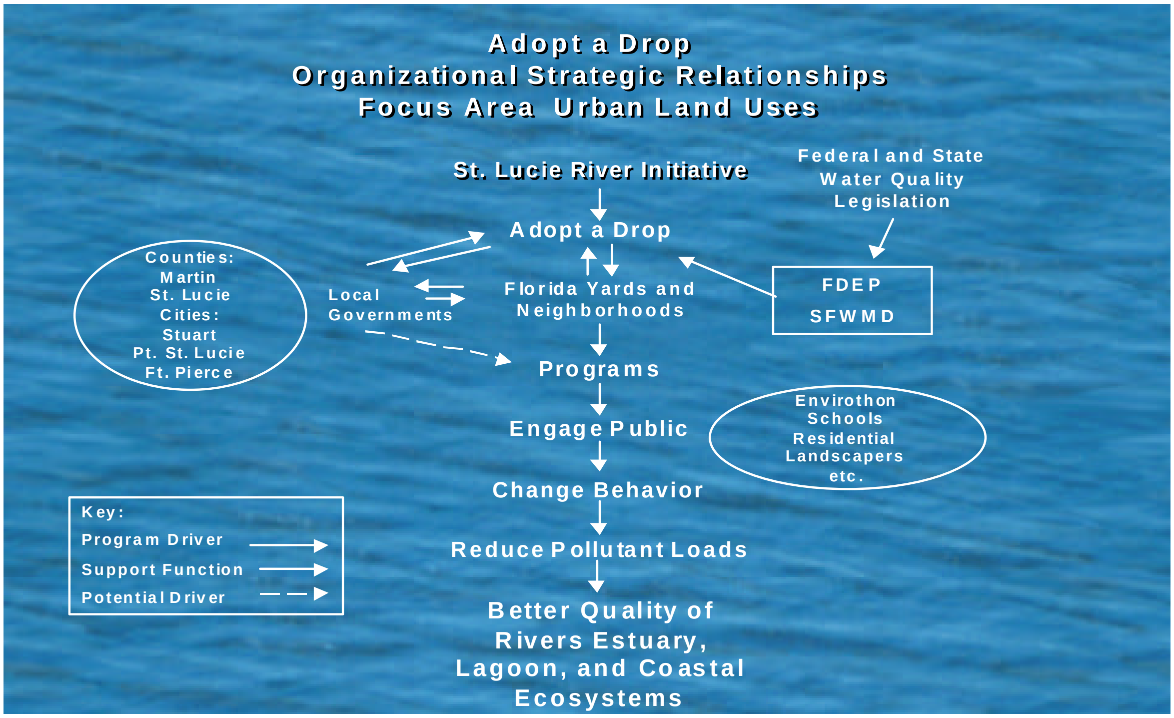


Figure 7-15.-- Adopt a Drop

This information can then be utilized by residents, homeowner associations, for immediate changes in cooperation with the IFAS, Florida Yards and Neighborhood (FYN) program. Local governments can utilize the information to develop plans and implement retrofit stormwater improvements. The FYN program is the primary cooperator in the implementation of this program. Additional support has been provided by SFWMD, FDEP, and the some local governments. This innovative program has been endorsed by the City of Stuart, Martin and St. Lucie Counties. Several neighborhoods have been enrolled in the pilot phase of the project.

The Initiative plans to evaluate the results of these early efforts, make changes as necessary, and then fully implement the program throughout the watershed.

Water quality improvements in the older urbanized portion of the watershed are extremely important since much of this area is directly adjacent to the SLE and River. Plans by local governments to implement stormwater retrofits, and elimination of widespread septic tank utilization will have a positive impact on water quality. However, providing the residents and businesses in this area with information about local hydrology and stormwater systems, and encouraging voluntary implementation of best management practices will continue to be a necessity, as population growth continues to impact this portion of the watershed.

Muck. Projects related to this issue are listed in Table 7.7 The general sedimentation pattern is one where coarse sand accumulates at areas of higher current velocity, with increasingly fine sediments deposited as currents decline. The areas of greatest muck sediment deposition are where the narrow areas of the North and South Forks widen, and where the Middle Estuary widens east of the Roosevelt Bridge. This SLE "ooze" is troublesome because it is unconsolidated and is easily re-suspended by wind or boat traffic. In a suspended state, it blocks light penetration adversely affecting seagrasses. It also smothers oyster and other benthic habitat, and is aesthetically very displeasing. Remediation or removal of muck and sediments is required to restore the health of the St. Lucie Estuary.

Excellent maps of muck sediments are found in Haunert (1988). Muck sediment accumulations during this century average 2-3 feet in most of the Estuary that is deeper than 6 feet. However, some local areas, such as the mouth of Poppleton Creek, now average only 3 feet deep, and are essentially choked with deep muck deposits (Henderson 2001). In September 2000, the United Army Corps of Engineers (USACOE) performed a muck survey in the SLE.

Table 7-7. Pollutant Load Reduction - Non-Point Sources–Muck Projects

Project Name	Description	Status	Lead Agency
USACOE Muck Survey	In support of the IRL Feasibility Study four areas in SLE were surveyed and mapped for potential muck removal. A total of 79 transects were established. Analysis of the data collected resulted in an estimate of 5,514,563 cubic yards of material. This is action is proposed as a remediation and habitat restoration element in the recommended plan.	Complete	USACOE
SLE Beneficial Reuse of Marine Muck	This project was a contract to IFAS, IRREC to provide information on the origin and chemical makeup of SLE muck/ooze and its potential for use as an agricultural soil amendment.	Complete	SFWMD
St. Lucie River Initiative / SFWMD Muck Removal Pilot Project	This joint project consists of dredging 1500 cubic yards of muck out of the South Fork of the St. Lucie River and barging it upstream for land disposal. A series of experiments will be performed by IFAS to determine potential utilization and disposal techniques for the material.	In progress	St. Lucie River Initiative & SFWMD

A variety of sediment/muck removal projects have been completed, or are under way, or are planned in the SLE Watershed. Muck removal is also planned as a part of the IRL South Feasibility Study. Four areas were identified in the Estuary where muck remediation was believed to be most advantageous: two in the North Fork, one in the South Fork, and one in the Mid-Estuary. The total muck volume in these four areas was estimated as 5.5 Million cubic yards, and the cost for muck remediation and habitat restoration was estimated as $105.5 Million. Muck remediation and habitat restoration as proposed in the IRL – South Plan will not occur until 2008 or later.

The St Lucie River Initiative (The Initiative) in cooperation with the SFWMD, IFAS, and others, has been actively pursuing better data on the characteristics, sources, and potential uses for SLE ooze, in anticipation of eventual removal as outlined in the CERP IRL South Plan. IFAS has recently completed a literature review, and field sampling and analysis of this material (He *et. al.* 2001). Based on the need for further information as to potential technologies for removal and disposition of muck, prior to the large scale restoration project envisioned in the CERP IRL – South Plan, a pilot study is currently underway. Dredging of approximately 1500 cubic yards of muck out of the South Fork of the St. Lucie River is underway and will occur in the summer of 2002. The muck will be transported inland and tested for use as pasture amendments and native land restoration materials. The project should be completed in 2004.

Septic Tanks. Pollutant loads from on-site disposal systems (OSDS), a.k.a. "septic tanks," or from inflows of groundwater contaminated by OSDS are considered by many to pose a potential threat to water quality in certain areas with close proximity to the lagoon and its tributaries. Projects that address this issue are summarized in Table 7-8. Conclusive evidence is not yet available, but results from ongoing groundwater monitoring studies being done by the SFWMD will soon provide data on both quantity and quality of water entering the estuary and Lagoon. These studies may provide additional insight into the potential impacts of septic tanks. Progress is also being made by local governments to identify priority areas, develop plans and obtain funding to convert OSDS to central sewer systems within the SIRL/SLE watershed.

One of the most ambitious efforts to reduce the impacts of septic tank systems on the SLE and River has been undertaken by the City of Port St. Lucie. The City has significant development and large drainage areas that are adjacent to the North Fork of the St. Lucie River. Although it may take another 3 or 4 years to finish construction, when completed about 95 % of the City's lots will have access to water and sewer infrastructure.

Table 7-8. Pollutant Load Reduction - Non-Point Sources–Septic Tank Projects

Project Name	Description	Status	Lead Agency
City of Port St. Lucie	This project will provide about 95% of the City with water and sewer service. Approximately 75% of the project has been completed to date.	In progress	City of Port St. Lucie
Martin County	The County has a formal Septic Elimination program and has evaluated feasibility of providing sewer service to 7,500 existing homes within the watershed. If a majority of residents request such a project and are willing to assume the hookup costs, the County will initiate planning and development for future infrastructure improvements.	In progress	Martin County
St. Lucie County	The County will evaluate the feasibility of providing sewer service to existing neighborhoods if a majority of the residents request such a project. The costs to residents often preclude initiation and development of widespread infrastructure improvements.	Case by case evaluation.	St. Lucie County

Extensive portions of Martin and St. Lucie Counties are served by individual septic systems. While both counties have acknowledged the need to decrease the use of septic tanks in environmentally sensitive areas, progress has been difficult. The septic systems of some neighborhoods along the SLE and the SIRL have been identified by county and state agencies as potential threats to water quality.

City of Port St. Lucie Aerial Photograph

The main impediment to discontinuing reliance on septic tanks is the costs. Martin County estimated it would cost about $82 million to provide sewer service to 7,500 homes in 13 riverfront neighborhoods currently served by septic systems. Martin County has a formal Septic Tank Elimination Program covering over 8,500 homes and discussions are underway concerning how best to make the transition in several subdivisions and older residential areas. Generally speaking counties have identified areas of greatest need, but without consensus from area residents and businesses, rapid progress is unlikely

Total Maximum Daily Loads (TMDLs). Portions of the St. Lucie River were placed on the FDEP Impaired Water Body List in 1998. Passage of the 1999 Watershed Restoration Act, has provided significant non-point source pollution abatement policy as well as establishing specific guidance and requirements for agencies and impacted stakeholders relative to both Pollution Load Reduction Goals (PLRGs) and TMDLs. Additional information of these processes and their relationships to IRL SWIM planning and projects was described in Chapter 6, Figure 6-8.

Monitoring, Modeling and Applied Studies

Information concerning the status and sponsors of monitoring, modeling and applied studies projects is summarized in Table 7-9.

Monitoring

In addition to the previously described existing monitoring networks, current plans are for a limited number of sites where large scale additional monitoring will be undertaken over the next several years. The North Fork of the St. Lucie River will be a primary area of focus of these efforts, based on the need to document the effectiveness and impacts of the Ten Mile Creek Critical Restoration Project, and the North Fork Floodplain Restoration Project and future CERP components. In addition, the adoption of Minimum Flows and Levels (MFLs) for the North and South Forks will identify future monitoring requirements. The continuing data requirements to develop PLRGs, and the need to characterize the impacts of BMP implementation, where possible, may also increase the need for monitoring. As a first step toward establishing pollution load reduction goals, it is necessary to quantify the relationship between external inputs to the estuary and water quality in the estuary.

Table 7-9. Monitoring, Modeling, and Applied Studies Projects

Project Name	Description	Status	Lead Agency
Monitoring Studies			
North Fork Nursery Study	Obtain physical, chemical and biological data from oligohaline areas of the North Fork, before and after Ten Mile Creek facilities are built, to support water quality models and define tem-poral and spatial relationships among flow and estuary flora and fauna.	In progress	SFWMD
Joint Pilot Projects - North Fork Floodplain Restoration Monitoring	SFWMD and FDEP project to monitor water quality and hydrol-ogy and conduct field surveys to test methods and define effects projects to reconnect areas of the floodplain to the North Fork.	In progress	SFWMD & FDEP @ PSL
Minimum Flows & Levels (MFL) Impact Assessment	Continue water quality monitoring and evaluation of future data to better define effects of MFLs on biota in the oligohaline zone.	In progress	SFWMD
St. Lucie River Watershed Assessment	Assessments of the C-25, C-23, C-44, and Tidal St. Lucie basins, and Basins 1, 4, 5, and 6	Complete	SFWMD
Citrus Herbicide and BMPs - Determine quality of off site discharges	Determine effect of groundcover management on loss of herbi-cides to irrigation and drainage ditches in two grove systems.	In progress	IFAS
Agrochemical and nutrient loadings in runoff from golf, urban, pasture water quality	Quantify nutrient and metal loadings from urban areas, golf courses, and pastures. Identify sites where pesticides in runoff may be a problem.	In progress	IFAS
NRCS Co-Op Study	Monitoring Floridan water use in cooperation with the Natural Resources Conservation Survey (NRCS)	Continuing	NRCS
Modeling Studies			
Watershed Water Quality Model Development	Currently in development, anticipated completion date for the development phase is 2002.	In progress	SFWMD
Estuary Water Quality Model Development	Currently in development anticipated completion date for the development phase is 2003.	In progress	SFWMD
Applied Studies			
BMPs for Citrus and Vegetable Crops to Improve Surface Water Quality	Demonstrate the effectiveness and desirability of applying newly developed best management practices for citrus and vegetable production system in the IRL/SLE Watershed	In progress	IFAS
Oyster Restoration Experiments – GLML.	Conduct experiments at the Gumbo Limbo Mesocosm Laboratory to evaluate oyster reproduction and environmental tolerance for various levels of salinity, temperature and disease.	In progress	SFWMD
In-situ Oyster Restoration Substrate Experiments	Field experiments to test the effectiveness of various artificial substrate materials to enhance oyster reproduction and growth.	In progress	SFWMD
Seagrass Restoration Experiments - GLML	Continue seagrass salinity experiments at Gumbo Limbo Meso-cosm Laboratory to focus on restoration parameters for the SLE.	In progress	SFWMD
Enhanced use of Citrus Pesticide BMPs in St. Lucie Estuary Watershed	Cooperative agreement with IFAS, IRREC to assess precision spray application to improve pesticide spray practices, reduce environmental contamination and sustain or improve efficacy.	In progress	SFWMD & IFAS
BMPs for citrus and vegetable crops to evaluate nutrient and metal loading	Characterization of nitrogen, phosphorus, and heavy metals in surface water runoff from citrus groves and vegetable fields in the IRL/SLE Watershed	In progress	IFAS
Environmental Toxicity in St. Lucie Estuary/Indian River Lagoon	NOAA study of adverse biological effects associated with chemical contamination	In progress	NOAA
Sediment Control BMP Evaluations for Indian River Citrus	Determine the effectiveness of water furrow sediment traps for reducing phosphorus and copper losses in runoff. Compare the amount of sediments released from grove ditches where water levels are controlled by screw gates and riser boards	In progress	IFAS
Upper East Coast (UEC) Water Supply Plan 1998	Establish a basis for future water use decisions to provide water supply for urban areas, agriculture, and the environment.	Complete	SFWMD

Some information on nutrient loading in the estuary exists based on water quality data collected by the District and other agencies. However, there are virtually no data that quantify the effects of nutrient load reductions on nutrient concentrations in the estuary. While the District has identified several components that are necessary to produce these estimates of load reduction goals, ultimately, computational models (under development by the District) will be required to predict estuarine water quality parameters as a function of external inputs, internal hydrodynamics and relevant processes and transformations occurring within the estuary. The calibration and verification requirements of two new models, the Watershed Water Quality Model (WaSh) and the Estuary Water Quality Model may require additional short term monitoring projects.

Finally, in addition to future requirements for monitoring that may arise as a result of implementing the CERP IRL – South Plan, there are on-going restoration and environmental enhancement studies, i.e., oysters, SAV, fisheries, nutrients, and fresh water inflows that will necessitate additional monitoring activity. The requirements for increased monitoring that may result from the TMDL process, such as designation of portions of the SLE & River as impaired waters on the FDEP planning list, cannot be evaluated at this time.

Modeling

Under the SWIM Program the SFWMD is mandated to develop Pollution Load Reduction Goals (PLRGs). Development and application of computer models is a critical step in accomplishing this goal. In order to evaluate the effectiveness of pollutant reduction strategies, the modeling efforts will include predicting estuarine water quality parameters as a function of external inputs, internal hydrodynamics, relevant processes, and transformations occurring within the estuary. The reliability of a receiving water model depends on the accuracy of freshwater input data. A receiving water modeling project can not succeed without dependable watershed input.

Hydrodynamic Estuary Model

Hydrodynamic modeling has been the primary tool used to understand changes within the South IRL and SLE. Modeling has been used to develop salinity-flow relationships under stable conditions and to study salinity shock within the estuary under storm-event conditions. The 2-D salinity model was developed by the SFWMD, based on combining features of two versions (RMA-2 and RMA-4) on a model that was originally developed for the Army Corps of Engineers by a consultant, Research Management Associates, Inc. The SFWMD hydrodynamic/salinity model covers the entire St. Lucie Estuary and a portion of Indian River Lagoon. See Chapter 6 for further discussion of this model. Model outputs have provided scientific support to the CERP – IRL–South Plan and system operations. The model was also adapted and extended to predict present and future salinity conditions for the St. Lucie River and Estuary MFL study.

Drainage canal discharge has a major impact on the salinity condition in the estuary. The estuary model was applied to various freshwater inflow conditions to establish a relationship between the magnitude of freshwater inflow and the estuarine salinity condition. The freshwater inflow included both surface and subsurface (groundwater) input to the estuary. Figure 7-16 is a mosaic of six salinity contour maps that show the trend of salinity declining when fresh water inflow increases. The Waterways Experiment Station (WES) of the United States Army Corps of Engineers (USACOE) is converting the existing St. Lucie hydrodynamics/salinity model to a three dimensional version that will be able to simulate salinity and temperature stratification and the formation and movement of a salt wedge. WES is also extending the model to cover the Indian River Lagoon between Fort Pierce Inlet and Jupiter Inlet (including Loxahatchee River).

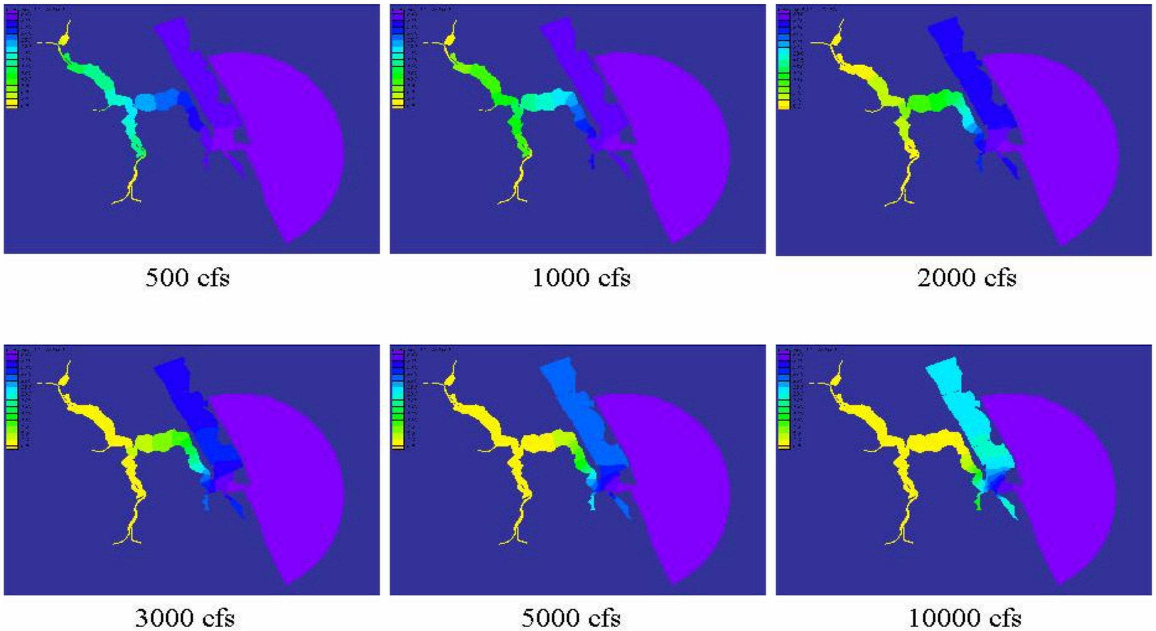


Figure 7-16. Sample output from the St. Lucie hydrodynamics/salinity model used to assess the effects of canal discharges on salinity gradients in the estuary.

Watershed Hydrology, Reservoir Optimization and Oyster Stress Models

Restoration of the SLE/IRL ecosystem is a major component of the Comprehensive Everglades Restoration Plan (CERP). During the restoration plan formulation, an integrated modeling approach was employed to establish the hydrologic restoration target and to refine the restoration alternatives. The plan focuses on hydrologic restoration to the pre-drained or natural hydrologic characteristics in the watershed to aid the recovery and protection of salinity sensitive biota in the estuary. To achieve this goal, a suite of models dealing with watershed hydrology, reservoir optimization, estuary salinity and oyster stress was applied. Results from the Natural Systems Model (NSM), which simulates the hydrologic response of the pre-drained watershed to recent climatic conditions, were used as the basis to establish the hydrologic restoration target, size reservoirs, and justify flow transfers between basins within the watershed. The Hydrologic Simulation Program - Fortran (HSPF) was used to simulate the hydrology of the present and future conditions. A genetic algorithm based optimization model (OPTI), coupled with HSPF, was used to size the storage reservoirs and generate operational rules that govern water release to the SLE. Finally, an estuary salinity model and an oyster stress model were used to develop a numerical performance measure to evaluate the effectiveness of the project on estuarine ecosystem restoration.

As noted, HSPF was applied to the South IRL watershed and SLE watershed for long-term hydrological simulations (from 1965 to 1995). The modeling characterizes the basins as combination of six land uses including irrigated agriculture (primarily citrus), non-irrigated pasture, forest, wetland, urban lands having an impervious surface, and urban lands have a pervious surface. The land-uses were based on GIS land-use coverages for the areas. Nine separate HSPF models were developed for each of the large SFWMD drainage basins including South Fork, North Fork, C-44, S-153, C-23, C-24, C-25, and Basin 1, as well as the three small drainage basins (Basins 4, 5, & 6) which were combined into a single model. Stream hydraulics was simulated for the primary canals in the basins and the hydraulic characteristics of the primary canal structures were simulated. Where possible, the HSPF models were calibrated against reliable flow and stream stage data. The models for C-23, C-24, C-25, and C-44 were calibrated. The calibrated model parameters from these basins were then applied to the non-calibrated basins of S-153, South Fork, North Fork, Basin 1 and Basins 4, 5, and 6 where no SFWMD water control structures are available. The uncontrollable portion of the SLE watershed comprises 128,000 acres or 26% of the entire 500,000-acre St Lucie watershed. In addition, the open water portion of the estuary has 5,900 acres that receive direct rainfall and evaporation.

Using HSPF, the SFWMD estimated the future (in the year of 2050) conditions with the consideration that there will be substantial increases in urban lands and a decrease in wetlands, forest and pasture areas.

The hydrology of the pre-developed SLE watershed was simulated using the SFWMD's Natural Systems Model (NSM). The NSM-SLE model is a relatively course (2 mile by 2 mile cells) finite element model that simulates all elements of the hydrologic cycle including groundwater flow and overland flow. The model uses the same rainfall and potential evapotranspiration data as the HSPF model. Watershed boundaries are different, with NSM-SLE boundaries being based only on topography. The NSM-SLE modeling results were used to size reservoirs, justify diversions and irrigation supplies, and establish minimum flows for SLE restoration. For example, the NSM-SLE model showed low flow rates entering the estuary during dry periods, implying that the estuary did not require flow augmentation during dry periods and, consequently, that irrigation demands were not competing with environmental demands from the estuary. The NSM-SLE model outputs were also used to drive hydrodynamic salinity models and oyster growth models.

Watershed Water Quality Model

The SFWMD initiated another model development project in 1999 in order to model watershed water quality. The URS Corporation developed a watershed hydrology and water quality model (WaSh) for use in areas that have dense drainage canal systems, high water tables, and multiple irrigation sources. The model has a cell-based representation of watershed surface where hydrology and water qualities are modeled with Hydrologic Systems Program Fortran (HSPF). The infiltrated water is routed to a groundwater model that represents the surficial aquifer. Runoff is routed to a drainage system model that has the capacity to simulate bi-directional flow, branches, and common flow structures. An Arcview Graphic User Interface (GUI) was developed to facilitate BMP implementation, land use changes, reservoir and stormwater treatment system operations that are key watershed management strategies in South Florida. The new model will be evaluated in the C-24 and North Fork basins before the end of 2002. The ultimate goal of this effort is to develop watershed management strategies to achieve PLRGs for the watershed.

***Applied Studies*.**

The South Florida Water Management District (SFWMD) has developed a comprehensive estuary research plan based on current ongoing activities and the identification of future information requirements.

Role and Importance of Oysters as a Valued Ecosystem Component

Studies indicate that the Middle Estuary contains the majority of the oyster resources in the St. Lucie Estuary. An analysis of inflows for 31 years (1965 to 1995) were modeled, daily salinity resulting from these flows for the middle estuary (Hu, 2001) indicated that existing water management practices frequently caused stress and lethal low salinity conditions for the SLE oyster population. The physiological response of oysters to salinity and season was estimated by using literature values. Additional analysis revealed that pre-drainage, natural watershed inflows would significantly reduce the occurrence of stress and death of oysters and, therefore, promote the existence of a healthy oyster population if suitable substrate is available (Haunert and Konyha 2000).

To date, restoration efforts for oysters in the SLE have been limited to reducing the frequency and duration of Lake Okeechobee inflows by changing floodwater management of the Lake. CERP will retrofit the hydrology of the SLE watershed to emulate natural inflow characteristics, improve water quality and virtually eliminate floodwater releases from the Lake to the estuary. Monitoring of health and utilization of oyster reefs is a measure of successful restoration. Since limited scientific information was available for this estuary it is important to acquire a better understanding of endemic oyster life history, salinity tolerances, and test technologies for the development of oyster reefs. A program to address the life history, salinity tolerance, health, and restoration techniques for the SLE oyster began in April 2000. Sampling sites within existing oyster reefs were selected in the North and South Forks as well as the Middle Estuary to provide information on water quality, gonad development, and recruitment of spat and presence of diseases (dermo). According to Creswell and Vaughan (1990), oysters spawn several times a year in Florida. Spawning begins in early spring (February to March) as water temperatures increase and continue through early summer and spawn again in the fall (September and October). Monitoring in the SLE showed major annual recruitment of spat began in April and peaked in May 2001. Since planktonic larval development usually takes about two or three weeks before metamorphosis to a spat (Kennedy. Chap 10, p372), spawning most likely began in early March and peaked in April, 2001.

Salinity in the SLE can decrease quickly at the oyster reefs from watershed runoff. It is critical that a thorough understanding is developed concerning the quantity of runoff, salinity at the oyster reefs and the response of the oysters to the salinity. Although considerable general information is available on the tolerance of oysters to salinity (URS Greiner Woodward Clyde, 1999), limited data exist on the relationship among salinity, temperature, duration and condition of this species. Laboratory studies at Gumbo-Limbo Research Facilities in Boca Raton, began in 2002 to determine this relationship using endemic oysters. Once a relationship is established, watershed runoff can be better managed to consider oyster salinity tolerances.

In order for spat recruitment to be successful, the appropriate substrate (cultch) must be available. Various substances have been used in oyster restoration programs with success including oyster shell and limestone rock. The cultch should be free of silt; however, a surface bacteria population is desirable. Since the major annual spat recruitment occurs in the SLE during April and May, pilot cultch reefs with various dimensions will be placed in the SLE in 2002. The pilot reefs will be placed in the middle estuary where salinity fluctuations are attenuated, near exiting reefs, where current velocity is favorable, and at a depth of about 1m below mean low water. These reefs will be kept silt free and will be monitored for recruitment of spat, species utilization and succession. Results from all these efforts will help define large-scale restoration once watershed flows can be managed appropriately.

Role and Importance of Submerged Aquatic Vegetation as a Valued Ecosystem Component

The 1997 SAV survey conducted by URS Greiner Woodward Clyde revealed very little SAV in the SLE. The SAV found during the survey was so sparse that only point locations (not beds) could be mapped. Very sparse distributions of SAV (primarily shoal grass) were present in the lower estuary. No SAV was documented in the middle estuary or North Fork. And only small patches of SAV were found in the South Fork (near the mouth of Danforth Creek). Probably the greatest limitation to SAV beds in the St. Lucie Estuary is the light available for photosynthesis. If light attenuation is not improved through CERP and other on-going restoration efforts, then the establishment of SAV in the St. Lucie Estuary will be limited. Current efforts are limited to periodic monitoring of the health and distribution of SAV.

Primary Production and Benthic Nutrient Flux.

This research quantifies internal nutrient loading from bottom sediments and determines the role this loading plays in supporting the production of organic matter in the system. The SFWMD has monitored water quality in the SLE for over a decade. While it is clear that the estuary exhibits the classic signs of eutrophication (large algal blooms and hypoxic and anoxic events), little is known about the nutrient loading from internal or external sources that may be the ultimate cause of these problems. This 3-year project addresses internal nutrient and oxygen cycling processes within the estuary and focuses on the production and respiration of organic matter by planktonic communities in the water column and bottom communities in the sediments. Internal loading of nutrients by bottom communities is also addressed.

It is critical to establish the link between material loading and water quality prior to, during, and following the hydrological modifications implemented during CERP. The results of this study help establish the current relationship between freshwater discharge and the dynamics of oxygen and nutrients in the St. Lucie Estuary. A before and after comparison allows researchers and planners to evaluate effects of modifications implemented during the restudy.

The project includes *in situ* measurement of planktonic productivity and respiration at four stations in the St. Lucie Estuary. At each station, vertical profiles of production and respiration of oxygen (light-dark bottle method) are obtained. Pertinent environmental data, such as salinity, temperature, photosynthetically active radiation (PAR), nutrient concentrations, chlorophyll *a* and the N and P content of suspended particulate matter are also obtained. Measurements were made on a monthly basis. Construction of production versus irradiance curves furnishes information about the physiological status of phytoplankton populations and the potential for light limitation.

At these same four stations, the exchange of plant nutrients and dissolved oxygen between bottom sediments and the overlying water column was measured using *in situ* chambers. Gas and nutrient fluxes will be measured monthly. Results of these measurements will allow investigators to determine the amount of phytoplankton production that is sustained by nutrients supplied by bottom sediments.

In addition, more intensive studies are conducted during two 8-week periods: one in the dry season and one in the wet season. Sampling of productivity and benthic flux is sampled at two stations on a weekly basis. These studies in concert with other projects addressing external loads furnish a more complete picture of nutrient cycling in the St. Lucie Estuary, and assist in water quality modeling and establishing PLRG s.

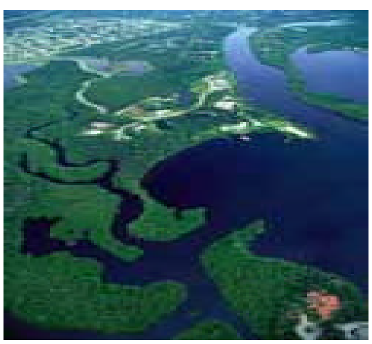
Preliminary analysis of the data collected during the productivity-benthic flux study provides some useful conclusions about nutrient cycling in the St. Lucie Estuary. This study clearly demonstrates the importance of the flux of nutrients from bottom sediments to the overlying water. First, the forms of nitrogen and phosphorus released from bottom sediments are readily available to primary producers in the overlying water. The primary productivity of plankton in the overlying water is limited by the supply of nitrogen and sediments in the St. Lucie are nitrogen rich. Secondly, the fluxes of these nutrients to the overlying water are high relative to other estuaries and high enough to support the rates of productivity observed during the study. The results to date suggest that nutrient management strategies need to focus on nitrogen and account for the large internal source from bottom sediments.

While evidence from water quality monitoring suggests that nitrogen is the nutrient that limits primary production, experimental data is required. Therefore, a nutrient addition bioassay, that examines the response of phytoplankton to nutrient additions (nitrogen and phosphorus) should be conducted. Sediments are clearly a major source of recycled nutrient. The response of the estuary to reductions in external loads depends on the magnitude and longevity of the sedimentary source. Mesocosm experiments or laboratory experiments with cores should be designed to address this question.

Minimum Flows and Levels

Minimum flows (MFLs) for the North Fork (21 cfs) and South Fork (7 cfs) St. Lucie Rivers and the Estuary were established during 2002, based on maintaining a sufficient area of low salinity (oligohaline) habitat to prevent significant harm from occurring to this resource. While the MFL is based on 'best available information', there are easily identifiable deficiencies. Foremost among these are: (1) a need for an enhanced modeling capability in the upper, low salinity zones of the estuary; and, (2) better flow and salinity data for the rivers and estuary, and (3) better biological data for the rivers and estuaries, including seasonal use of the oligohaline zone and salinity needs of benthic, planktonic and nectonic species and communities.

North Fork of St. Lucie River.



North Fork St. Lucie River

A significant portion of the floodplain of the North Fork St. Lucie River is completely or partially isolated from the river's main branch because of dredging conducted during the 1920s through the 1940s. FEDP Projects are underway to determine the effectiveness of various restoration strategies and techniques. The North Fork Reconnection Pilot Study is nearly completed. Three breaches were installed in June, 2002 at a 25-acre island and fish and vegetation monitoring will continue. The North Fork Oxbow Reconnection and Feasibility Study has yet to begin. During the next year, a contractor will analyze the feasibility of the complete restoration of the North Fork and also reconnecting one oxbow endpoint. The feasibility plan will encompass topography, hydrology, and natural community elements. Proposed restoration plans include spoil bank breaching with creeks or culverts, oxbow reconnections, and oxbow creation in the Five and Ten Mile Creeks

http://www.sfwmd.gov/org/wrp/wrp_ce/projects/oxbow.html
http://www.dep.state.fl.us/coastal/sites/indianriver/

The North Fork Nursery Study is designed to obtain physical, chemical and biological information in the oligohaline portion of the North Fork, before and after the Ten Mile creek attenuation facilities are constructed in the drainage basin. This information will be used for a water quality model and to define the temporal and spatial relationships among flow and estuarine flora and fauna. The synthesis and interpretation of the information obtained from this study will also support the development of water management recommendations for refining MFL criteria and operational guidelines for controlled releases from CERP facilities and wetlands. http://www.sfwmd.gov/org/wrp/wrp_ce/projects/n_fork_nursery.html